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Design and Fabrication of Coconut Dehusking Machine

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Abstract - This paper presents the development of a coconut dehusking machine with an optimized design. The components of the machine include a metal frame, an electric motor, a pulley, rollers with sharp edges, a roller with flaps, a spur gear, a hopper, and a bearing. The metal frame provides support, and all components are mounted on it. Two rollers are mounted adjacent to each other on the metal frame using bearings, and the metal roller with a flap is connected to the motor used to maintain contact between the roller and the coconut. A reduction gearbox is used to reduce RPM and provides sufficient torque from the motor. A Hopper with a circular shape is used to drop the coconut into rollers for safety purposes. Rollers peel the husk with the help of rollers. The coconut exits the rollers without a manual operator, making the de-husking process safer, less labor intensive, and more effective.

***Key Words*:** Labour-Intensive, Optimized design, Metal Frame, Dehusking, Metal roller, Metal frame, More effective.

1. INTRODUCTION

The coconut (Cocos nucifera) is one of the most versatile and widely utilized fruits in the world, playing a crucial role in various industries, cultures, and economies. Native to tropical coastal regions, the coconut palm is often referred to as the "tree of life" due to its extensive applications in food, health, industry, and environmental sustainability. Every part of the coconut tree, from its roots to its leaves, holds significant value, making it an indispensable resource for millions of people worldwide. The fruit itself is a drupe that contains a hard outer shell, fibrous husk, refreshing coconut water, and nutritious white flesh, each of which has multiple uses across different sectors. Coconuts serve as a major source of food and nourishment, contributing to balanced diets in many tropical regions. Coconut water is a natural electrolyte-rich drink, while the edible flesh is consumed fresh or processed into coconut milk, flour, and oil. Coconut oil, known for its unique composition of fatty acids, is widely used in cooking, skincare, hair care, and traditional medicine. Additionally, coconut-based ingredients enhance the flavor and texture of various culinary dishes, both sweet and Savory. Beyond its dietary significance, the coconut has extensive industrial and commercial applications. The husk's fibrous material, known as coir, is used for making ropes, mats, brushes, mattresses, and eco-friendly biodegradable products. The hard shell finds use as fuel, in handicrafts, and in activated carbon production for filtration systems. Even the leaves and trunk of the coconut palm are utilized in construction, furniture-making, and biofuel production, highlighting the plant's sustainable and zero-waste potential. Coconuts also hold deep cultural and religious importance in many societies. In countries such as India, Sri Lanka, and the Philippines, the fruit is often used in religious rituals, festivals, and ceremonies as a symbol of purity, prosperity, and divine blessings. The coconut tree's resilience and ability to thrive in harsh coastal conditions make it a symbol of endurance and abundance. This project focuses on improving the coconut dehusking machines to enhance efficiency, reduce manual labor, and improve productivity. Traditional dehusking is labor-intensive, making mechanized solutions essential for a faster process

2. LITERATURE REVIEW

Coconut dehusking is an essential process in the coconut industry, and various studies have been conducted to develop efficient and cost-effective machines to perform this task. The literature presents multiple designs and innovations in coconut dehusking technology.

Spiked Roller Mechanism for Dehusking

Rishikesh et al. [1] developed an electric-powered coconut dehusking machine that utilizes a spiked roller mechanism. The coconut is placed between two rollers, where a lever mechanism applies force, allowing spikes to pierce into the husk. The non-spiked roller rotates the coconut, while the spiked roller continues piercing, leading to dehusking. This approach ensures efficient shell breakage and dehusking through continuous rotary motion.

Low-Cost Dehusking Machine

Dany Thomas et al. [2] designed a low-cost coconut dehusking machine using cutting spines and a spur gear chain drive powered by an electric motor. Their review suggests that the machine is simple to operate and requires minimal maintenance, making it an affordable and practical solution.

Motorized Dehusking Machine Performance

Engr. John Paul et al.. [3] introduced a motorized coconut dehusking machine and analysed the effects of angular speed on dehusking capacity. Their findings show that operating at 60 RPM results in a high dehusking capacity of 271 nuts per hour. Furthermore, a nominal coconut diameter of 212 mm yields an even higher dehusking rate of 278 nuts per hour.

When combining these factors, the machine achieves a peak dehusking rate of 285 nuts per hour, demonstrating the impact of speed and coconut size on performance.

Semi-Automatic Dehusking Machine

P. Rajamani et al.[4] developed a semi-automatic coconut dehusking machine operated through manual power. Their experimental results indicate that this machine can dehusk approximately 2-3 coconuts per minute, providing an alternative to fully motorized dehusking systems while maintaining efficiency.

Preliminary Design Considerations

Mohd Azwir Azlan et al. [5] conducted a preliminary design study on a coconut dehusking machine, emphasizing the importance of material selection and mechanical components. Their research highlights the need to understand material properties and process suitability. Future improvements in their design will focus on reducing noise to make the machine more environmentally friendly.

Portable Dehusking Machine for Copra Coconut

Muhammad Faisal et al. [6] fabricated a portable coconut dehusking machine specifically designed for copra coconuts. Their model effectively performs piercing, peeling, and shearing operations, enhancing dehusking efficiency while improving user-friendliness. The modifications in their design aim to make the machine more efficient and accessible for widespread use.

High-Capacity Dehusking Machine

Alexander Pascua et al. [7] designed a coconut dehusking machine with a capacity of 240 coconuts per hour. The machine is designed for operation by a single person, significantly reducing labor requirements. Compared to traditional manual dehusking, which requires two to three operators, this machine enhances productivity while minimizing manual effort. However, operator skill remains a key factor in determining machine performance.

Chain Sprocket Mechanism for Dehusking

Mr. Pankaj et al. [8] designed a coconut dehusking machine driven by a chain sprocket mechanism. This system employs a sharp circular blade for dehusking, ensuring precision and efficiency. The machine is relatively inexpensive and accurate; however, drawbacks include susceptibility to dirt accumulation due to lubricants, frequent maintenance requirements, and operational noise.

3. METHODOLOGY

The process begins with problem identification and requirement analysis, focusing on improving traditional dehusking methods by reducing manual effort. The design phase involves selecting a 150W reduction motor to provide controlled power, which is transmitted through a gear train mechanism attached to metal spikes for efficient husk removal. To maintain consistent contact between the coconut and the spikes, a rotating rubber flap is incorporated, ensuring effective dehusking. Additionally, a hopper system is designed to facilitate the smooth feeding of coconuts into the machine. All components, including the motor, gear train, metal spikes, rubber flap, and hopper, are securely mounted on a sturdy metal frame for stability and durability. The fabrication phase involves machining, assembling, and integrating these components, followed by rigorous testing and performance evaluation to assess dehusking speed, efficiency, and reliability. Adjustments are made to optimize the gear ratio, spike placement, and rubber flap movement to enhance overall performance.

CAD MODEL

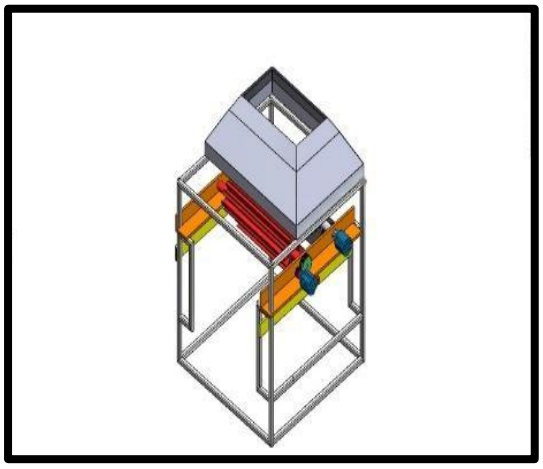

FIGURE 3. (A) *ISOMETERIC VIEW OF COCONUT DEHUSKING MACHINE*

4. CALCULATION

Torque Calculation

The force required to remove the husk depends on the binding strength of the coconut fibres.

From literature values:

Force (F) = 500 N

Torque (T) = (15 – 50) Nm

The torque is calculated as:

$$T = F \times Re$$

were,

F = 500N

Re = Effective Radius (Shaft Radius + Metal Spike Height)

$$T = 500 \times 0.10 = 50 \text{ Nm}$$

Velocity at Metal Spike

Substituting values:

$$P = \frac{2 \times \pi \times 15 \times 50}{60} = 78.5W$$

Linear velocity at the metal spike is given by:

$$V = \frac{\Pi dn}{60}$$

were,
D = Diameter of the roller = 0.1 m
N = RPM of the metal spike = 15

$$V = \frac{\pi \times 0.1 \times 15}{60} = \frac{0.0785\ m}{s}$$

Power Calculation

Power is calculated as

$$P = \frac{2\pi NT}{60}$$

Substituting the values

$$P = \frac{2 \times \pi \times 15 \times 50}{60} = 78.5W \approx 100W(0.13HP)$$

For smooth operation, a 0.2 HP (150W) reduction motor is selected.

Gear Ratio Calculation

To reduce the motor speed from 100 RPM to 15 RPM, the required gear ratio is:

$$\text{Gear Ratio} = \frac{Nm}{Ns}$$

were,

N_m = Motor Speed = $100\ RPM$

N_s = Speed of Metal Spike = $15\ RPM$

$$\text{Gear Ratio} = \frac{100}{15} = 6.67$$

Driving Gear (attached to motor shaft) = $15\ teeth$

Driven Gear (attached to the output shaft) = 15×6.67

$$= 100.05 \approx 100\ teeth$$

Efficiency Calculation

The efficiency (η) of the coconut dehusking machine,

$$\eta = \left(\frac{\text{Output Power}}{\text{Input Power}}\right) \times 100$$

Input Power (P_{in}) = 150 W (Motor Power)

Output Torque (T) = 50 Nm

Output Speed (N_s) = 15 RPM

Output Power Calculation

Output Power (P_{out}) is given by:

$$Pout = \frac{2\pi NsT}{60}$$

Substituting values:

$$P = \frac{2 \times \pi \times 15 \times 50}{60} = 78.5W$$

Efficiency

$$\eta = \left(\frac{78.5}{150}\right) \times 100 = 52.33\%$$

5. ANALYSIS

Calculation of force acting on the metal spike while dehusking the coconut

Torque (T) = 50 Nm

Effective Radius (R_e) = 0.10 m

Force Calculation

$$\mathbf{F = \frac{T}{Re}}$$

$$\mathbf{F = \frac{50}{0.10} = 500N}$$

The force of 500 N acts radially outward on the metal spikes during the dehusking process. This force is evenly distributed among the 15 spikes present in the dehusking mechanism.

Force per spike = $\left(\frac{500}{15}\right)$ = **33.33 N** Per Spike.

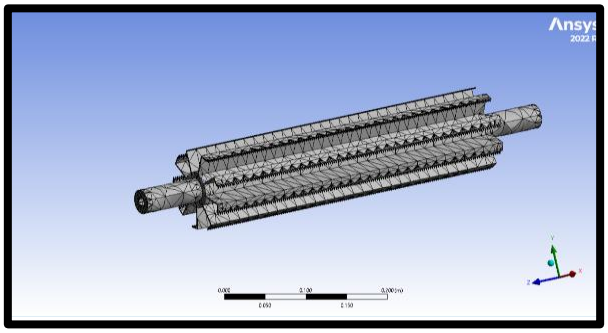

FIGURE 5. (A) *MESHING OF METAL SPIKE*

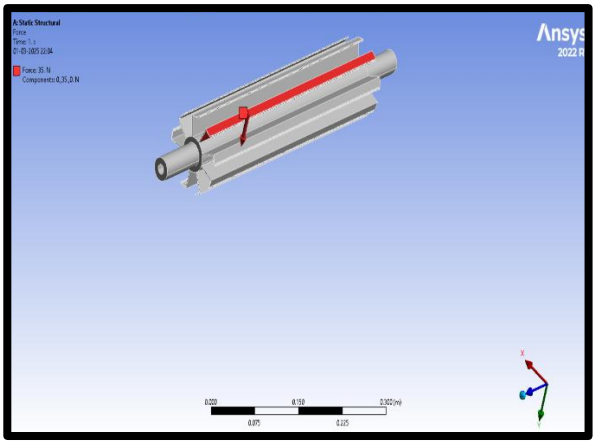

FIGURE 5. (B) *BOUNDARY CONDITION*

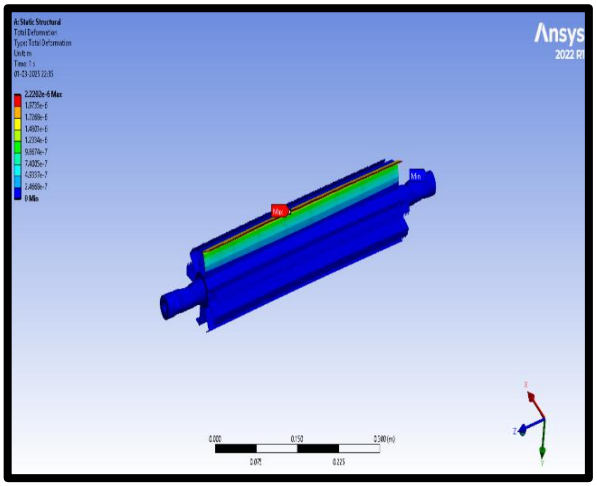

FIGURE 5. (C) *TOTAL DEFORMATION*

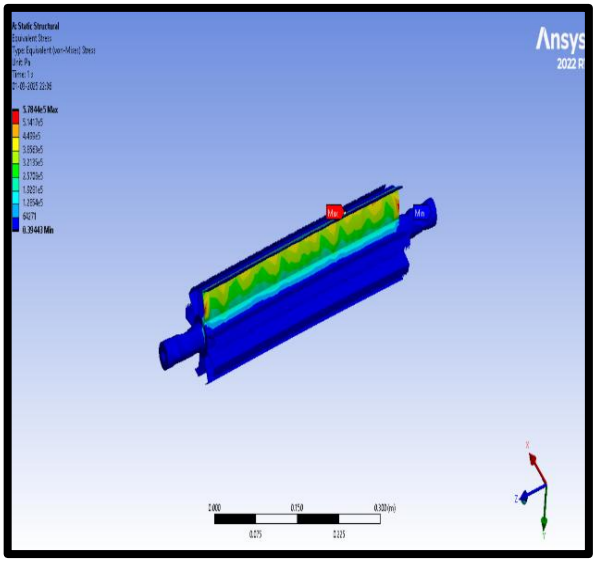

FIGURE 5. (D) *VON MESS STRESS*

The ANSYS structural analysis for the coconut dehusking roller, made of stainless steel, evaluates both total deformation and equivalent (von Mises) stress distribution under operational loading conditions. The maximum deformation observed is **0.00222 mm**, occurring at the top surface near the metal spikes, indicating minimal deflection and high structural rigidity. The stress analysis shows a maximum von Mises stress of **0.5784 N/mm²,** with the highest concentration around the spiked region where force is applied for dehusking, while lower stress values are observed near the shaft ends. The results confirm that the stainless-steel roller can withstand operational forces without significant deformation or failure.

6. SPECIFICATIONS

TABLE - 1: Specification of Machine

PARAMETER	VALUE
Torque	50Nm
Motor Power	0.2 HP (150 W)
Roller Speed	15 RPM
Radius Used	0.10m

7. RESULT AND DISCUSSION

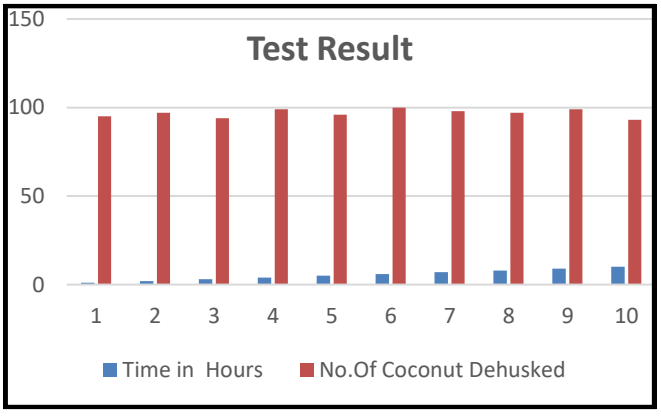

FIGURE 7. (A) *RESULT GRAPH*

The Test Result graph represents data collected over multiple trials, showing the number of coconuts dehusked and the time taken for each trial. Across different trials, the machine consistently dehusked 90 to 100 coconuts, despite variations in thickness and size. The time taken remained relatively low, indicating the efficiency and reliability of the mechanism. These results confirm that the dehusking machine performs consistently across different conditions, making it suitable for handling coconuts of varying dimensions with minimal fluctuations in processing time.

8. FABRICATED MODEL

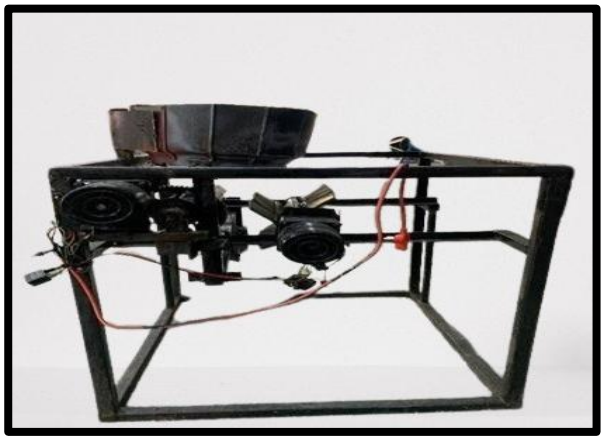

FIGURE 8. (A) *SIDE VIEW*

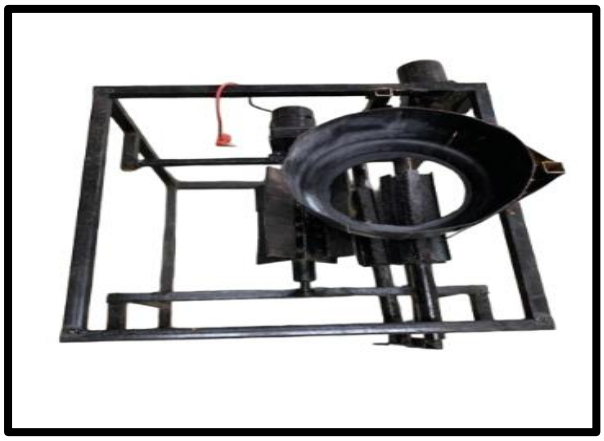

FIGURE 8. (B) *TOP VIEW*

9. CONCLUSION

The coconut dehusking machine has been successfully analyzed for torque, power, velocity, and efficiency. The calculations confirm that the machine requires 50 Nm of torque and a 500 N force to effectively remove the husk, with each spike experiencing 33.33 N. The system operates with a 52.33% efficiency, ensuring effective energy utilization.

The structural analysis using ANSYS verifies the durability of the stainless-steel roller, with minimal deformation of 0.00222 mm and a maximum von Mises stress of 0.5784 N/mm², confirming the component's strength under operational loads.

Performance testing shows the machine consistently dehusks 90 to 100 coconuts across different trials, regardless of variations in thickness and size. The time taken remains low, demonstrating high efficiency and reliability. These results confirm that the dehusking machine is structurally sound, energy-efficient, and capable of handling coconuts of varying dimensions effectively, making it a viable solution for coconut dehusking applications.

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